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CASTANEA

The Journal of the Southern Appalachian Botanical Club

Vol. 14 December, 1949 No. 4

Some Stages in the Development of Sphagnum Bogs In West Virginia

G. B. Rigg and P. D. Strausbaugh

Introduction

Sphagnum bogs are numerous in the eastern portion of West Virginia. The region in which most of them occur is mountainous and comprises Greenbrier, Pocahontas, Nicholas, Webster, Randolph Tucker and Mineral Counties. Several of the bogs are in the Allegheny Mountain region and are not far from the Virginia line. Some bogs or early stages in their development are also found in Mercer, Monroe and Preston Counties, and one considerable growth of *Sphagnum* occurs in Upshur County. The various bog stages discussed in this paper, with the exception of Uncle Beecher's Rocks, occur at elevations varying from 2,560 to 3,400 feet. These rocks have an elevation of 1,448 feet at the base and 1,750 feet at the top.

Darlington (1943) has published an account of the vegetation and substrate of Cranberry Glades and has cited the literature. Strausbaugh has spent a good deal of time during his more than twenty years at West Virginia University in studying the vegetation of all portions of the state in both its taxonomic and ecological aspects and has published a paper (1934) on Cranberry Glades. The authors of the present article visited a number of bogs and other plant communities that are of interest in connection with them in July, 1941. The term sphagnum bog has been defined by Rigg (1925) and the definition has been quoted by Carpenter (1938) from List P-1 of the Ecological Society of America.

The writers wish to express sincere thanks to Dr. E. L. Core for suggestions concerning nomenclature, to Dr. A. LeRoy Andrews for determining the species of *Sphagnum*, to Dr. Paul H. Price for information on the geology of the region, to Dr. John A. Gibson, Jr. for fur-

nishing photographs, to Mr. Clarence Muhlick and Mr. J. W. Thompson for redrawing and lettering graphs, and to the United States Weather Bureau for furnishing weather data.

All stages in the development of sphagnum bogs seen by the writers in West Virginia except the *Sphagnum* near Cheat Bridge and that on Beecher's Rocks occur in open places locally called *glades*. In some cases (Little Droop Glade and Big Droop Glade) the sphagnum bog covers practically the whole glade whereas in others (e.g., at Cranesville) the earlier stages in bog development occur as numerous small patches of *Sphagnum* in an extensive glade. Perhaps an adequate idea of the term glade as used in West Virginia may be given by saying that it designates level swampy areas whose vegetative cover may be entirely herbaceous or may consist also of scattered shrubs or shrubs and trees. The term is not limited to areas in which *Sphagnum* grows.

Descriptions of Stages in Development

Cheat Bridge. —The earliest stage in sphagnum bog succession seen in the state (elevation 3,550 feet) is near Cheat Bridge Post Office in Randolph County near the Pocahontas County line. Living *Sphagnum* is fairly abundant over an area of perhaps 100 acres of fir (*Abies balsamea* (L.) Mill.) forest from the base of Gaudineer Knob to Cheat Bridge. The robust green *Sphagnum* grows on the ground and on down timber and logs. The one specimen collected here was *S. imbricatum* var. *affine* (Ren. and Card) Warnst. The evidence that it is spreading is clear, but it has not formed any appreciable quantity of peat. It has not exercised any selective influence on the flora and there is no positive evidence that it will ever do so. The reason for the inclusion of this area in the descriptions of stages in bog development is that in both North America and Europe *Sphagnum* does grow in forests to such an extent that under some conditions it eventually kills the trees by "swamping" and then develops a bog. Auer (1933) discusses this mode of formation of bogs under the head of "paludification" of forest land.

Green Bank. —There was formerly an early stage in bog succession in a glade near Green Bank in Pocahontas County, but in 1941 it had dried to such an extent because of clearing and drainage that very little of the *Sphagnum* or other bog vegetation remained.

Uncle Beecher's Rocks. —Living *Sphagnum* occurs here on ledges, and in recesses on a conglomerate cliff (elevation 1,448 to 1,750 feet) near French Creek in Upshur County. It has exercised

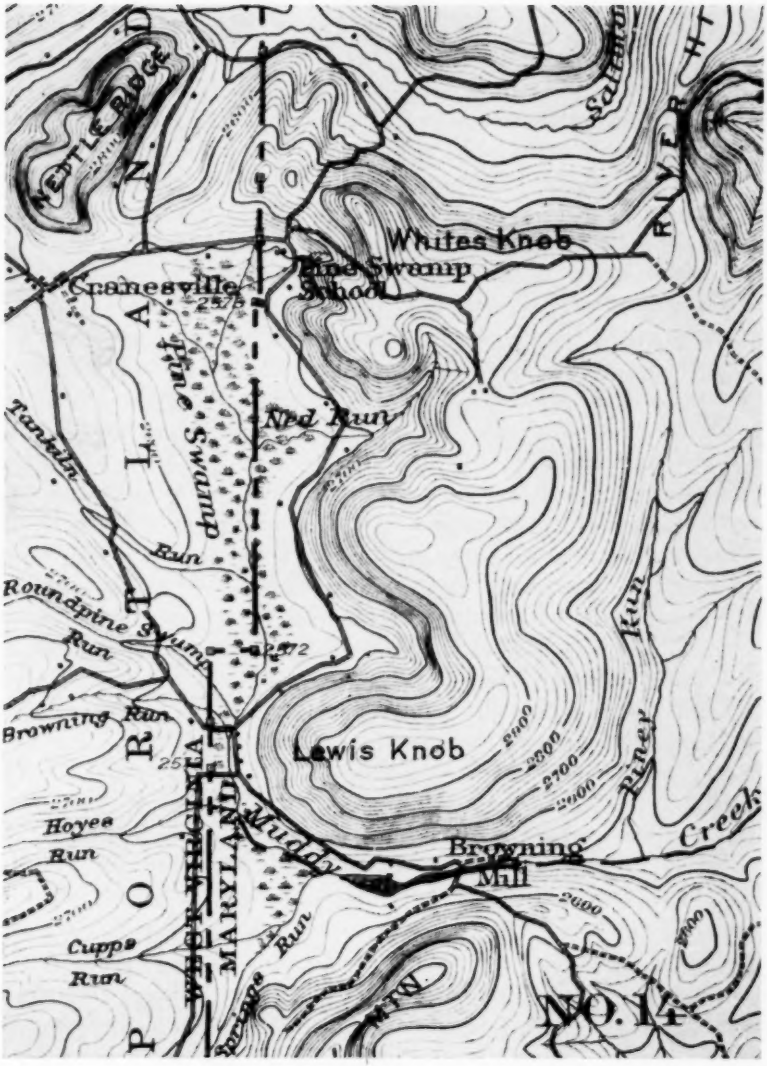

Fig. 1. Topography of Cranesville Glade and its environs. A portion of Accident Quadrangle. U. S. Geological Survey.

little if any selective influence on the flora. It does not at present constitute a climbing bog, since the extensions of living *Sphagnum* on the vertical surfaces of the cliff are small and are not continuous.

Cranesville. —Pine Swamp, near Cranesville (elevation 2,560 to 2,580 feet), is mainly in Preston County, West Virginia, but extends also somewhat into Maryland (fig. 1). It is about 10 miles northeast of Terra Alta. It is flat and a little over two miles long and from one-fourth to one-half mile wide. Muddy Creek, a sluggish stream of dark brown water, originates by two heads in the north end of the swamp and flows entirely through it and on into the Youghiogheny River in Maryland.

This swamp is superimposed on Greenbrier Limestone and some distance below the place where Muddy Creek flows into Maryland the stream has cut a narrow channel in the more resistant Pocono Sandstone. This more resistant rock has held back the stream flow, and the resultant poor drainage is responsible for the formation of the swamp, or glade. Of course the accumulated remains of the plants that have grown in the swampy area have further held back the stream flow. As the numerous patches of *Sphagnum* have developed on the swamp their large water-holding capacity has been a considerable factor in the retention of water.

This area is ecologically a swamp since the ground is saturated with water throughout much of the year, but during at least most of the year the surface of the ground is not deeply submerged. This is in accord with the definition of the term swamp as quoted by Carpenter (1938) from List R-1 of the Ecological Society of America. Muddy Creek has not formed levees of any consequence and at ordinary water level the surface of the water in the creek is about six inches below the surface of the swamp. At ordinary water levels the main portion of the swamp is undrained except by seepage, but at higher water levels there is probably some flow of water into Muddy Creek and its tributaries.

Sphagnum occurs in many places in this swamp, growing vigorously in patches varying from a few square feet to several square rods in area. Of the 16 specimens collected, 7 were *S. recurvum* Beauv., 4 were *S. capillaceum* var. *tenellum* (Schimp.) A. L. Andrews, 4 were *S. magellanicum* Brid., and one was *S. palustre* L. Some of these patches are flat, while others are in the form of hummocks 2 or 3 feet high. These hummocks consist mainly of the remains of many years' growth of *Polytrichum* sp. with *Sphagnum* growing over them. In some places

Sphagnum has also grown over old stumps and down timber and logs or around the bases of shrubs.

These flat patches and hummocks of *Sphagnum* have exercised some selective influence on the community of plants occupying them. Only six of the many species of vascular plants in the swamp community occur commonly in the *Sphagnum*-dominated areas. They are running swamp blackberry (*Rubus hispidus* L.), creeping snowberry (*Chiogenes hispidula* (L.) T & G.), goldthread (*Coptis trifolia* (L.) Salisb.), round-leaved sundew (*Drosera rotundifolia* L.), cotton grass (*Eriophorum virginicum* L.), and skunk cabbage (*Symplocarpus foetidus* (L.) Nutt.). Running swamp blackberry occurs in more of the *Sphagnum* patches than any of the other five species and is also more abundant in the ones in which it occurs. All six of these swamp species are here selected by the *Sphagnum* since they survive in it while other species in this swamp rarely survive where the growth of *Sphagnum* is dense.

The plant community of the swamp in which these patches and hummocks of *Sphagnum* have developed and on which they are now spreading is a swamp forest considerably modified by logging which was evidently begun a good many years ago. Old stumps are abundant and there are a good many old down logs, but many young trees uninjured by the logging have now attained considerable size. The most abundant tree species is hemlock (*Tsuga canadensis* (L.) Carr.) and there are many stumps and some down logs of this species. Other conifers more or less abundant are red spruce (*Picea rubra* (Du Roi) Dietr.), white pine (*Pinus Strobus* L.), black larch (*Larix laricina* (Du Roi) Koch.), and Canada yew (*Taxus canadensis* Marsh.). Broad-leaved trees are scattered throughout the swamp. The ones most commonly observed are red maple (*Acer rubrum* L.), wild red cherry (*Prunus pennsylvania* L. f.), sweet birch (*Betula lenta* L.), and yellow brich (*B. lutea* Michx. f.).

Among the larger shrubs scattered throughout the swamp are winterberry (*Ilex verticillata* (L.) Gray.), mountain holly (*Nemopanthus mucronata* (L.) Trel.), speckled alder (*Alnus incana* (L.) Moench.), arrow-wood (*Viburnum dentatum* L.), withe-rod (*V. cassinoides* L.), witch-hazel (*Hamamelis virginiana* L.), American mountain ash (*Pyus americana* (Marsh.) DC., black chokeberry (*Pyrus melanocarpa* (Michx.) Willd.), purple fruited chokeberry (*Pyrus arbutifolia* (L.)L.f.), great laurel (*Rhododendron maximum* L.), and mountain laurel (*Kalmia latifolia* L.). Among the other species in the

swamp are small cranberry (*Vaccinium Oxycoccos* L.), cat-tail (*Typha* L.), a golden rod (*Solidago uniligulata* (DC) Porter.), sedges (*Carex spp.*), a spike rush (*Eleocharis* sp.), a club moss (*Lycopodium annotinum* L.), cinnamon fern (*Osmunda cinnamomea* L.), and royal fern (*O. regalis* L. var *spectabilis* (Willd.) Gray.).

Little Droop. —Little Droop Bog (locally known as Little Droop Glade) occupies a depression about 500 feet long and 15 to 80 feet wide, one end of which is close to Highway 219 in Pocahontas County not far from Droop Mountain Battlefield. Droop Mountain is a massive accumulation of White Medina Sandstone, a very resistant rock, and the shallow depression occupied by the bog is in this material. A small stream flows from the bog, but the very resistant rock has made cutting extremely slow and the depression remains poorly drained. In this bog there is an abundance of living *Sphagnum* which, with sedges and other plants of similar habit, has formed a mat over shallow water. The Sphagnum has exercised considerable selective influence on the species composing the plant community of the bog. Small cranberry, large cranberry (*Vaccinium macrocarpon* Ait.), and running swamp blackberry are common. Other species characteristic of bogs and other wet places are a beak rush (*Rynchospora capitellata* (Michx.) Dahl.), a sedge (*Carex angustior* Mackenzie), a club rush (*Scirpus sylvaticus* L.), a bog rush (*Juncus acuminatus* Michx.), and turk's cap lily (*Lilium superbum* L.). The two erect woody species are black chokeberry and winterberry.

Big Droop. —Big Droop Bog (locally known as Big Droop Glade, elevation 3,060 feet) is on Droop Mountain southwest of Hillsboro in Pocahontas County, near the Virginia line, just east of Highway 219. It is about one-fourth of a mile long and about 100 to 125 yards wide. It occupies a depression in the White Medina Sandstone of the mountain. What drainage it has is through the same stream that flows along Little Droop Bog. The slowness of cutting in this resistant material accounts for the continued existence of the depression. The drainage from both of these bogs eventually, through being tributary to other creeks, reaches the Greenbrier River. Most of the streams of this region originate in springs, but the writers have not traced this stream to determine its specific origin.

This bog except for occasional pools of open water is covered by a sedge-*Sphagnum* mat in which *Sphagnum* is growing vigorously. Of the 9 specimens of *Sphagnum* collected in various portions of this bog, 5 were *S. recurvum*, 3 were *S. palustre* L., and one was *S. capilla-*

ceum var. *tenellum* (Schimp.) A. L. Andrews. Among the species of the sedge family (*Cyperaceae*) which are growing in the mat and have probably contributed to its formation are *Carex crinita* Lam., *Scirpus cyperinus* (L) Kunth., *Rynchospora alba* (L.) Vahl., *Dulichium arundinaceum* (L.) Britton, *Eriophorum virginicum* L., *Eleocharis tenuis* (Willd.) Schultes, *E. obtusa* (Willd.) Schultes., and *calva* Torr.

Among the other herbs present in the mat are a bog rush (*Juncus acuminatus* Michx.), grass of Parnassus (*Parnassia asarifolia* Vent.), skunk cabbage, round-leaved sundew, yellow fringed orchis (*Habenaria ciliaris* (L.) R. Br.), grass pink (*Calopogon pulchellus* (Sw.) R. Br.), and a chain fern (*Lorinseria areolata* (L.) Presl.). Under this mat are 3.5 to 4.5 feet of black, watery, slimy material which comes under von Post's (1924) fifth class of peat as to water content, which he characterizes as "water with peat slime." This bog is in an early shrub stage, but the herb stage, as indicated by the list above, is still represented by many species and individuals, and the invasion of trees has begun.

The erect shrubs are mountain laurel, great laurel, withe-rod, black chokeberry, and swamp rose (*Rosa carolina* L.), Among the woody vines are running swamp blackberry, checkerberry (*Gaultheria procumbens* L.), large cranberry, and small cranberry. The trees present are not large and are not crowded together. The species are red spruce, hemlock, pitch pine (*Pinus rigida* Mill.), white pine, red maple, and black gum (*Nyssa sylvatica* Marsh.).

Cranberry Glades. —These glades (elevation approximately 3,400 feet) are in the Allegheny Mountains region and are 20 miles from the Virginia line. They are in Pocahontas County, 9 miles from Marlinton. Darlington (1943) classifies the entire level area of approximately 600 acres in and adjoining these glades as bog. There are four open areas covered with mosses, lichens and sedges which are popularly known as glades—Big Glade (60 acres), Flag Glade (28 acres), Long Glade (20 acres), and Round Glade (8 acres). Darlington recognizes five plant communities and associations—shrub, *Carex-Sphagnum*, *Sphagnum-Vaccinium-Rynchospora*, *Polytrichum-Cladonia*, and bog forest. The two shrub communities (*Alnus-Sambucus* and *Alnus-Viburnum*) cover about 400 acres and the bog forest about 80 acres.

Darlington found peat varying in thickness from a few inches to 11 feet covering most of the 600-acre area. He made 5 transect profiles, boring about 150 holes with a Hillier peat borer. The layers of peat which he found at a station in Big Glade, in order from top to bot

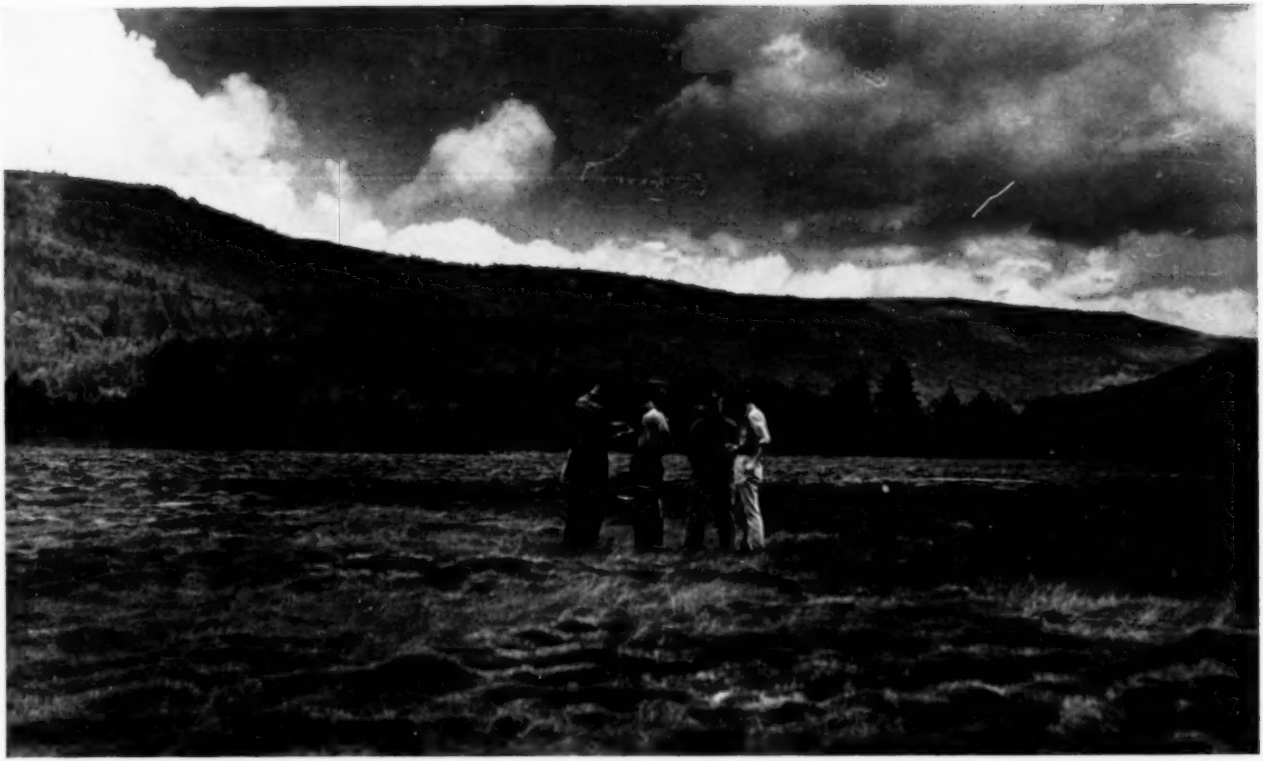

Fig. 2. The moss-lichen carpet in Cranberry Glades. The dark vegetation behind and to the right of the group of men is **Andromeda glaucophylla.** May, 1947. Photograph by John A. Gibson, Jr.

tom, and their thickness in feet are: *Sphagnum* peat 2, sedge and *Sphagnum* mixed 3, sedge 2, algal ooze 4. Under the peat was a layer of marl 3 feet thick and under the marl was clay one foot or more in thickness.

The writers made 10 collections of *Sphagnum* in Cranberry Glades comprising 8 species and varieties—*S. recurvum, S. recurvum* var. tenue, *S. capillaceum* var. *tenellum, S. palustre, S. magellanicum, S. imbricatum* var. *affine, S. squarrosum* Crome, and *S. Girgensohnii* Russ. In one collection *S. palustre* and *S. recurvum* occurred together and in another collection *S. magellanicum* and *S. recurvum* var. *tenue* occurred together. In all other cases only one species or variety was found in each collection. Darlington reports that *Sphagnum* grows over much of the forest floor in the bog forest association, that *S. capillaceum* and *S. palustre* are present throughout the *Sphagnum-Vaccinium-Rynchospora* area, that *S. palustre* grows over much of the *Alnus-Viburnum* community, and that the *Sphagnum* in the *Carex-Sphagnum* community is mostly *S. capillaceum* with some *S. palustre.*

The writers believe that the bogs described above show the main features of West Virginia sphagnum bogs. Ecological and physiological studies of other bogs in the state would, however, be desirable and would no doubt contribute new data and new points of view.

Local Climate and Soil Temperatures

The only available data which give an adequate idea of weather conditions in West Virginia bogs are those from the Weather station at the Federal Prison which is about half a mile from Cranberry Glades and at approximately the same elevation (3,400 feet). These data indicate severe weather conditions. Low temperatures, cloudy days, abundant precipitation, and heavy snowfall are reported. All temperatures here given are in degrees Fahrenheit and, unless otherwise stated, all data are averages for two years (1945 and 1946). The mean monthly temperatures were: January 26.6°, February 32°, March 46.7°, April 50.4°, May 53.2°, June 60.70°, July 63.5°, August 61°, September data for 1946 partly missing, October 48.7°, November 40.6°, December 28.4°. The mean annual temperature for 1945 was 46.4°. The maximum temperature during the two years was 88° (July and August, 1946) and the minimum was 18° below zero (January, 1946). In 1945, 27.7 per cent of the days were clear, 36.7 per cent were partly cloudy, and 35.6 per cent were cloudy. The data on clear days and cloudy days for 1946 are partly missing.

Precipitation of 0.01 inch or more fell on 40 per cent of the days. The annual precipitation was 47.6 inches, distributed as follows: January 4.38, February 4.52, March 3.97, April 3.56, May 5.79, June 3.21, July 6.14, August 2.15, September 4.06, October 1.62, November 4.67, December 3.60. The total snowfall for 1945 was 78.4 inches and for 1946 was 44.9 inches. There was no snowfall in December 1946, but in December 1945 it was 31.7 inches. Four inches of snow fell in April 1946, but only a trace in April 1945. The period between killing frosts for 1945 is reported as 81 days (June 7 to August 27). In 1946 the minimum temperature on June 6 was 29°. On August 27, it was 32° and an September 1, 21°. The period during which the tem perature was not below freezing was thus 87 days.

These data give a general picture of weather conditions for the year, but day by day conditions during the growing season are much more important for the growth of plants. This is especially true of maximum and minimum air temperatures. Freezing air temperatures occurred on four different dates (6, 22, 23 and 30) in May and on two different dates (5 and 6) in June. Besides these, temperatures of 40° or below occurred on ten different dates (4, 5, 7, 8, 9, 13, 18, 19, 29, 31) in May and on seven different dates (7, 10, 22, 23, 24, 25, and 27) in June. The maximum temperature was 80° or above on twelve days (7, 8, 9, 11, 17, 18, 19, 20, 25, 26, 29, 30) in June and did not reach 80° at any time in May. Extreme differences between maximum and minimum temperature for the same twenty-four hour period are worthy of note. A difference of 47° occurred on two days (22 and 30) in May and one (6) in June, and differences of 40° or more occurred on eight other days (May 6, 23 and 31, June 7, 10, 11, 24, 25) during the two months. Other data on weather conditions during the growing season of 1946 are shown in table I.

The available data on soil temperatures in West Virginia bogs are given in Darlington's paper on Cranberry Glades. He ascertained temperatures with a soil thermometer at a station where 2 feet of *Sphagnum* was underlaid with mixed sedge and *Sphagnum*, sedge, algal ooze, and marl. His determinations were made between 2:00 p. m. and 4:30 p. m. The time of day at which they were made indicates that those at the surface were close approximations to the maximum temperatures for the 24 hours. They were made at the surface and the 6-inch depth, then at one-foot intervals down to 10 feet, on 17 dates

Table I

Weather conditions during the growing season at the Federal Prison station near Cranberry Glades, West Virginia, 1946

	Maximum temp.	Minimum temp.	No. of days 70 or above	No. of days 32 or below	No. of clear days	No. of partly cloudy days	No. of cloudy days	No. of days with 0 01 in. or more precip.	Maximum precip. in 24 hours	Total precip.
April	82	16	15	13	10	10	10	8	1 33	3.44
May		28	14	4	9	9	13	14	1.15	5.15
June	83	29	26	2	7	13	10	10	1.26	3 35
July	88	39	30	0	2	19	10	9	1.95	4.43
August	88	32	23	1	9	11	11	8	0.51	1.87

Table II

Temperatures in degrees Fahrenheit of the substrate at a station in Cranberry Glades at the surface and the 6- and 12-inch depths Data from Darlington. Discussion in text.

Depth	April 12	May 18	June 22	July 13	August 12	August 23	September 4	September 27
Sur.	32	58	61	63	67	67	68	60
6 in.	37	56	59	62	66	65	66	57
12 in.	40	55	57	58	64	61	63	55

from April 12 to November 11. Data for the surface and the 6-inch and 12-inch depths on a sufficient number of dates to indicate the general seasonal trend of temperatures are given in table II. The data given in this table are approximations read from the graphs in figure 12 of Darlington's paper. Darlington checked the temperatures shown in his figure 12 by making determinations in other communities in Cranberry Glades and found that only the surface temperatures varied from those shown in his figure. The data in table II show low temperatures in April with a rapid rise to May, followed by a somewhat less rapid rise to August and a rapid fall in September.

Discussion

Physiographic origins.—The depression in which the West Virginia sphagnum bogs described in this paper are developing are traceable to (1) natural depressions in rock which have persisted because relatively hard rocks have resisted stream cutting, and (2) levees caused by aggrading along the margins of streams.

The rocks involved in the persistence of depressions due to the slow cutting of streams are mainly sandstone, limestone, conglomerate and shale. The simplest type of persistent depression is illustrated by those in which Little Droop Bog and Big Droop Bog are developing. Here only one kind of rock is involved. The depressions are in the very resistant Pocono Sandstone and their persistence is due to the slowness of stream cutting in this material. A slightly different type occurs where two kinds of rock, one very resistant and the other only slightly resistant, are found. This is illustrated by the origin of the poorly drained area in Pine Swamp in which the swamp community has developed and on which there is now an early stage of bog development. The swamp rests on Greenbrier Limestone but its drainage is limited by the slowness of the cutting of the stream which drains it in bordering Pocono Sandstone. Differential rates of cutting by streams in strata of various degrees of resistance was also a factor in the earlier physiographic history of Cranberry Glades. Details of this based on several years of study are given by Darlington. The strata involved are mainly sandstones, limestones, conglomerates, and shales

The origin of undrained areas as a result of aggrading by streams is seen in Cranberry Glades. Levees built up by this aggrading have left undrained areas behind them in which bogs have developed. Details of this have been worked out by Darlington. He says, ". . . the main peat accumulations are located in the angles of the junctions

of the streams" and "levee building . . . has now probably ceased in most parts of the bog."

All of the modes of origin of undrained areas in which the bogs of West Virginia described by Darlington and by the present writers are developing are seen elsewhere in North America. Details are different but the general modes of origin are similar. Auer (1933) and others have described physiographic origins of undrained areas in which bogs have developed and one of the writers (Rigg) has unpublished data on such origins.

The origins of bog Communities. —Sphagnum bog communities in West Virginia so far as seen by the writers are originating in two ways, (1) by the formation of mats on water. (2) by the enroachment of *Sphagnum* on swamp communities or other plant communities. The first is seen in Little Droop Bog and Big Droop Bog, and the second is seen in Pine Swamp and also at various places in Cranberry Glades. In Little Droop and Big Droop the present stage of development indicates clearly the origin of the mat on the shallow water by the growth of sedges and other similar plants accompanied or preceded by *Sphagnum*.

In Pine Swamp it is evident that the spreading patches of *Sphagnum* will eventually cover the area unless interfered with by man or by some natural changes which are not now foreseen, and the whole swamp will develop into a sphagnum bog. The drainage barrier here created the conditions for the development of the swamp community and the *Sphagnum* community is now developing on it.

The origin of sphagnum bog communities in Cranberry Glades is somewhat more complex than in Pine Swamp. More plant communities are involved in Cranberry Glades than in Cranesville Glade and the tension lines between *Sphagnum* communities and the other communities in the former are mostly irregular as compared with the small circular tension lines in the latter.

Darlington set stakes on the borders of various zones in Cranberry Glades and observed changes in their borders over a period of 8 years. He found that "*Sphagnum* had spread several feet into a pure *Carex rostrata* community and an *Alnus-Viburnum* community." He found also that "Shrubs are encroaching on the moss-lichen, the cranberry-beaked rush, and the sedge-*Sphagnum* communities" and that "The bog forest is encroaching on every side of the area . . ." He says, "It is only a question of time until the shrubs will cover the whole 600 acres, gradually to be replaced by bog forest." This general

picture of the development of the herb, shrub, and forest stages beginning with the invasion of *Sphagnum* and culminating in a bog forest is similar to the course seen in various stages of bog development in other regions of North America (Rigg, 1940, 1940a, and the literature there cited).

In addition to the general lines of succession indicated in the above paragraph a number of interesting local invasions and competitions are found in Cranberry Glades. One of these is the invasion by bog rosemary (*Andromeda glaucophylla* Link.). This northern bog species whose reported southern range (Robinson and Fernald, 1908) extends as far as New Jersey has established colonies in the *Polytrichum-Cladonia* association in Big Glade in recent years. It has spread rapidly and is still spreading. Strausbaugh examined this association in 1926 and did not find any bog rosemary present then. He noted it at later dates and found that it was spreading rapidly in 1941 and 1947. Darlington (1943) reports the presence of 3 colonies and states that "It has greatly increased its area in the last 10 years, suggesting that it was introduced by bird dissemination of seeds from some other bog." The rate of advance by two woody species which were apparently present when the flora was first studied was measured by Darlington. He found that checkerberry spread 10 feet in 8 years into the *Polytrichum-Cladonia* association and that a St. John's-wort (*Hypericum densiflorum* Pursh.) had advanced 17 feet into the same association during the same period. Among the local competitions on which data are recorded by Darlington are those between *Carex* and *Sphagnum* and between *Polytrichum* and *Sphagnum*.

Floristics. Vascular plants.—A floristic comparison shows striking similarities between the sphagnum bogs of West Virginia and those of other portions of North America. This is shown mainly by the fact that 14 species occurring in West Virginia bogs are well known bog species in other portions of North America. These are round-leaved sundew, large cranberry, small cranberry, creeping snowberry, bog rosemary, a beak rush (*Rynchospora alba*), skunk cabbage, yellow fringed orchis, grass pink, grass of Parnassus, buck bean (*Menyanthes trifoliata* L.), black larch, pitch pine, and red maple. The first 11 of these either have the habitat "bogs" or "*Sphagnum*" according to Robinson and Fernald (1908) or are included in the list of species characteristic of sphagnum bogs by Rigg (1940a). The last 3 are discussed by Rigg (1940). Some of these 14 species (e.g. round-leaved sundew and small cranberry) are characteristic of sphagnum bogs throughout most

of the bog regions of North America, while others (e.g. creeping snowberry and red maple) occur in more limited portions of the bog region of North America either in bogs or outside of them.

The floristic similarity between the West Virginia sphagnum bogs and other North American sphagnum bogs is also shown by the fact that several genera, not including any of the genera to which the 14 species mentioned above belong, are represented by one or more species in West Virginia bogs and by another (or others) in other bogs of North America. Herbaceous examples are *Eriophorum virginicum* in West Virginia and *E. Chamissonis* C. A. Mey. and other species elsewhere; *Rubus hispidus* in West Virginia and its congener of similar habit *R. Chamaemorus* L. elsewhere; *Gentiana clausa* Raf. in West Virginia and *G. Douglasiana* Bong. and *G. Sceptrum* Griseb. in Pacific Coast bogs; *Carex crinita* Lam., *C. folliculata* L., *C. rostrata* Stokes, *C. trisperma* Dewey and other species in West Virginia and *C. tenuiflora* Wahlenb., *C. laricina* Mack., *C. pauciflora* Lightf., *C. paupercula* Michx., and *C. phyllamonica* W. Boott in bogs farther north and west. Among the shrub genera is *Kalmia* which is represented by *K. latifolia* in West Virginia bogs and by *K. polifolia* Wang. in bogs farther north. Among the tree examples are *Betula lutea* and *B. lenta* in West Virginia and *B. glandulosa* Michx. and *B. occidentalis* Hook. elsewhere; and *Tsuga canadensis* in West Virginia and *T. heterophylla* (Raf.) Sarg. in Pacific Coast bogs. These are merely a few examples. They do not constitute a complete list.

The communities of plants found in West Virginia bogs show northern affiliations. Six species having extensive distribution northward are south of their range as given by Robinson and Fernald (1908) and are not in Small's Flora (1933). They are buckbean, two species of manna grass (*Glyceria canadensis* (Michx.) Trin. and *G. laxa* Scribn., a bulrush (*Scirpus atrocintus* Fernald), a bog rush (*Juncus filiformis* L.), and black larch. Some of these are not far beyond their previously reported southern range while others are some distance south of it. All of them except the bog rush and the bulrush have been reported for West Virginia by Core (1940). Another northern species (*Carex canescens* L.) is close to its reported southern limits for eastern North America. Mackenzie (1940) reports its range southward to Virginia. Four other species occurring in West Virginia bogs whose range as given by Robinson and Fernald and by Small includes West Virginia are much more generally distributed north of West Virginia than south of it. They are large cranberry, creeping snow-

berry, round-leaved sundew and a beak rush (*Rynchospora alba*).

Another evidence of the northern affiliations of the plant communities of Cranberry Glades with those of northern regions is the extensive area covered by the moss-lichen community which is tundra-like in aspect (fig. 2). Plant communities similar to this one are extensive in the sub-arctic regions ofNorth America and occur in bogs at least as far south as southern Canada.

The various evidences discussed above do not constitute a complete statement of the evidences for the northern affiliations of the plant communities of West Virginia bogs, but further particulars are unnecessary. Since the region in which most of the West Virginia bogs occur is mountainous and the weather is cold, cloudy and wet, the conditions are favorable for the growth of species of colder regions northward.

Sphagnum.—All of the 9 species and varieties of *Sphagnum* known to occur in West Virginia bogs show much more general distribution north of West Virginia than south of it. One variety (*S. recurvum* var. *tenue*) is south of its previously reported range. The distributional data from Blomquist (1938) for the species and varieties of *Sphagnum* occurring in the southeastern states indicate a less general distribution of the West Virginia species and varieties in the southern portion of this region than in the northern portion. Some are distributed only as far south as North Carolina and Tennessee and others are found at higher altitudes. The data from Frye (1918) for western North America indicate general distribution of the West Virginia species and varieties northward to Alaska and southward to California for some and only to Oregon or Washington for others. One variety occurring in West Virginia bogs is not reported by Frye for western North America, but he reports the species as extending north to Alaska. The range of the West Virginia species and varieties given by Andrews (1913) indicates general distribution northward to Labrador or Greenland or Newfoundland or Eastern Canada and southern distribution as far as New Jersey or Virginia for some and Florida, Mississippi, Louisiana, or Texas for others.

The southern distribution of *Sphagnum* (not the West Virginia species and varieties in all cases) is further indicated by several reports. Murrill (1938) reports 5 species in one county in Florida. Ruth Svihla in a letter to Rigg in 1947 reports the occurrence of *Sphagnum* in swamps in Louisiana. Andrews reports 12 species in Florida, 5 in Louisiana, one in Mississippi, and one in Texas. Though these re-

ports show considerable southern distribution of *Sphagnum*, it is evident from the literature that the distribution of species and varieties of this genus is much more general northward than southward. *Sphagnum* requires a relatively cool and moist environment for its growth. Such conditions are found in some places in the southern states, but so far as known to the writers such areas are mostly small and relatively scarce. In the mountainous region of eastern West Virginia these conditions are common and extend over considerable areas.

Kinds and range of bogs. —Both flat bogs and raised bogs are found in West Virginia. Little Droop and Big Droop are flat. Both raised and relatively flat bogs occur in Cranberry Glades (Darlington, figs. 5 to 10). The occurrence and relative positions of the strata of *Sphagnum* peat, sedge peat, and the mixture of these two as well as the presence of clays of several colors under the layers of organic materials are similar to their occurrence elsewhere in North America (Rigg, 1940a, and the literature there cited).

So far as known to the writers the West Virginia bog region contains more numerous and more extensive sphagnum bogs and shows later stages of maturity than any other region of the United States that far south. It is known, however, that sphagnum bogs do occur farther south. So far as known to the writers these are relatively small and are in comparatively early stages of development. H. L. Blomquist in a letter to Rigg in 1941 says, "There are in my opinion no extensive sphagnum bogs in North Carolina. However, there are numerous boggy areas where some *Sphagnum* grows and these areas vary a good deal." He made a map showing 6 boggy areas in western North Carolina and 5 in the region from Durham County southward to Columbus County. Undoubtedly the local occurrence of *Sphagnum* and the extent to which it forms bogs in North Carolina, South Carolina, Georgia, Alabama, Florida, Louisiana, and Texas would be a good field for ecological investigation. On the Pacific Coast of the United States the most southerly bog reported is located about 125 miles north of San Francisco, close to the ocean (Rigg, 1933).

Factors in bog development in West Virginia. —Three main factors favor the development of sphagnum bogs in West Virginia: (1) Geologic structure and physiographic changes have created undrained or poorly drained areas which have remained through long periods of time. (2). The local climate especially at relatively high elevations at some places in the mountainous regions of the eastern portion of the state is extremely cold, cloudy, and wet. (3) The soil

temperatures are favorable for the growth of species characteristic of sphagnum bogs and of northern regions. Details of these factors have been given earlier in this paper, and the facts about the first two are obvious without further discussion. Soil temperatures, however, merit further consideration.

These soil temperatures are, in general, in line with soil temperatures in sphagnum bogs in other portions of North America (Rigg, 1947). There are at least three possible factors in the production of these low soil temperatures in West Virginia: (1) local climate, (2) cold water which flows into the bogs from numerous springs, (3) the well known physical properties of *Sphagnum* and the peat strata which underlie it. Darlington emphasizes the second factor. He says, "The temperature of the bog soil is no doubt influenced by the water from hundreds of cold springs which flows into it, especially from Cranberry Mountain. The temperature of the spring water changes but little during the 12 months (44° to 54°). This water tends to maintain uniform temperature in the bog throughout the year, especially at the lower levels."

There can be no doubt that this cold water is an important factor, but local climate, of course, determines the seasonal rise and fall of soil temperatures at the depths at which the roots of most bog plants grow. There was, for instance, a rise of 29° at the 6-inch depth between April 12 and August 12 (table II), while the total annual variation in the temperature of the spring water was only 10° (Darlington). At successively deeper levels the seasonal variation in soil temperatures found by Darlington was less and less until at 10 feet the total annual change was only about 5°, and the maximum occurred in October. This is characteristic of peat soils and is due to the well known physical properties of *Sphagnum* and the strata of peat that lie under it. It seems evident that the limiting factor in the seasonal variations of soil temperatures in the upper layers of the bogs of Cranberry Glades is local climate, and that the summer temperature may be lowered somewhat by cold water from springs, and that the physical property of the soil is a factor at all seasons.

Summary

1. Sphagnum bogs are common in cold mountainous regions in eastern West Virginia.

2. Stages in development from the mere presence of *Sphagnum* to fairly mature bog stages occur.

3. The courses of development of sphagnum bogs in West Virginia are similar to those found elsewhere in North America.

4. The sphagnum bogs of West Virginia are more extensive and show later stages of maturity than any known bogs farther south.

5. Three factors favor the development of sphagnum bogs in the eastern portion of West Virginia: (a) The presence of numerous undrained or poorly drained areas. (b) The cold, cloudy, wet climate of many of these areas. (c) The low soil temperatures of the peat which accumulates as the bogs develop.

6. The depressions in which sphagnum bogs in West Virginia have developed are traceable mainly to (a) differences in resistance of limestones, sandstones, shales, and conglomerates to stream cutting, and (b) levee building, or aggrading, along the banks of streams.

7. The origins of the sphagnum bog communities existing at present in West Virginia are accounted for mainly by (a) the encroachment of *Sphagnum* and the vascular species which accompany it on other plant communities, and (b) the formation of sedge-*Sphagnum* mats over water.

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UNIVERSITY OF WASHINGTON, SEATTLE
AND
ORLANDO, FLORIDA

NOTES and NEWS

WILBUR H. DUNCAN, *Editor*

PRESENTING SOUTHERN APPALACHIAN BOTANISTS

Associated with School of Forestry, University of Georgia:

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Book Review

AMERICAN WILD FLOWERS*

The most recent addition to the voluminous literature dealing with wild flowers of North America was published by D. VanNostrand Company on July 8 as the first number of their new series of books on native plants and animals, *The New Illustrated Naturalist*.

The present book is unusual among flower guides because of the large territory it covers, since Dr. Moldenke, the author, states that it includes plants from the United States, Canada, St. Pierre, Miquelon, Alaska and Greenland. The species described were selected as a result of a questionnaire sent to 1100 naturalists, asking them to list 12 of the most conspicuous or interesting plants of their region. Over

*American Wild Flowers. Harold N. Moldenke. D. Van Nostrand Company, Inc. 455 p. $6.35. 1949.

half of these questionnaires were returned and more than a thousand different plants were then added by the author, so that, in all, 2950 different plants are treated. The book is illustrated by 88 full-color plates and 67 plates in black and white.

The species are discussed in phylogenetic order, arranged in families according to the Bessey system. One or more families are included in each of the 50 chapters. No keys are given and it is apparent that use of the book assumes a considerable knowledge on the part of the reader. It would seem that the principal value of the work lies in the information it gives as to the particular *species* of a known *genus* to be found in a particular *section* of the region covered. For instance, if the reader knows already the genus *Actaea*, he may determine that the plant in Alberta or Alaska should be called *A. arguta*. Of course, there is a possibility that the plant found might not be named in the book at all, since the work makes no pretense of being complete.

Although Dr. Moldenke has traveled widely and has seen many of the plants described, growing in their natural habitats, he has had to depend for much of his information upon other works and his book is to a certain extent a compilation from many sources. In addition, the chapters are opened and closed by quotations from celebrated authors in appreciation of nature.

To the present reviewer the book will have its greatest value as a compendium in one volume of information concerning the plants of widely separated regions not before so grouped. It would be helpful to carry along as a general guide in making a tour of the country. It would not be of much aid, however, in a detailed study of the plants of any particular section.

In its manufacture the book is quite attractive and, despite its rather high price, it is predicted that it will soon occupy a prominent place in nature libraries throughout North America north of Mexico.

—Earl L. Core

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